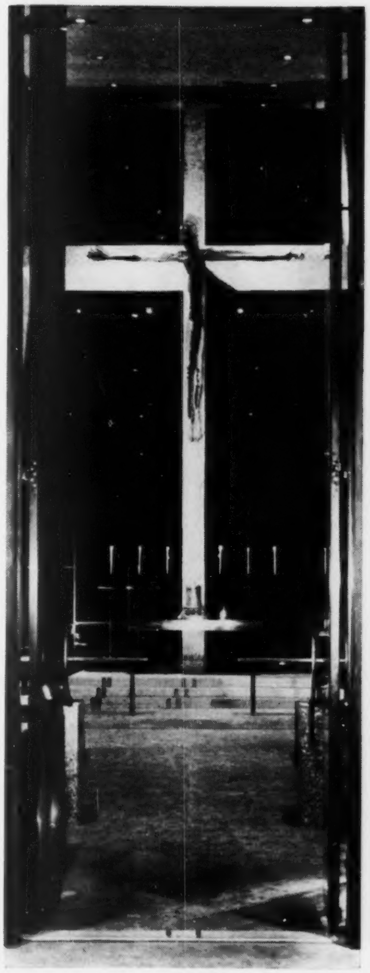
Desert Chapel of Poured Concrete

BY KENNETH R. MACDONALD



ONE OF THE WORLD'S most spectacular religious structures, the $250,000 Chapel of the Holy Cross, just completed on the Arizona desert near the little town of Sedona, is a monument not only to its donor but also to the power and the beauty inherent in concrete. Designed by the San Francisco architectural team of Robert S. Anshen and William S. Allen, the new chapel was built by the William Simpson Construction Company of Los Angeles.

The task of building the chapel on rugged Arizona terrain to which modern equipment was unadaptable, and where utilities were lacking, was in itself a notable achievement. The site is among the richly eroded sandstone formations of Arizona's Oak Creek Canyon, adjacent to twin buttes which rise 300 feet above the valley floor and which are joined by a rocky spur to a 1,500 foot cliff beyond. Perfectly integrated into the site, the chapel seems to rest firmly between the twin buttes and at the same time to soar upward from them.

The dominant visual element is likewise the chapel's major load bearing structural element, a 90-foot high cross which extends down 30 feet below the main floor of the chapel in a cleft between the buttes.

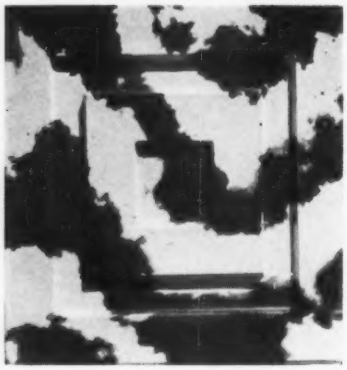
The structure is 62 feet long and measures 26 feet across at its widest point, with the exterior side walls continuing back outside the structure. A ramp or walkway which ascends in graceful curves from the road to the entrance plaza adds grace to the architect's overall design.

A new road swings around the 3 sides of the monument until it approaches from the East. From an automobile turnaround at that point, the ramp swings up to the plaza, some 30 feet above where the worshipper sees the entrance side for the first time.

In the center of the entrance are double doors of black anodized aluminum, 21 feet high and only 4 feet wide, with the great cross at the other end, surrounded by glass. The altar, a 2-ton slab of marble which measures 8 feet by 3 feet by 8 inches thick, is cantilevered from the cross on which is pinioned a sculpture in welded black steel by San Francisco's famed artist, Keith Monroe.

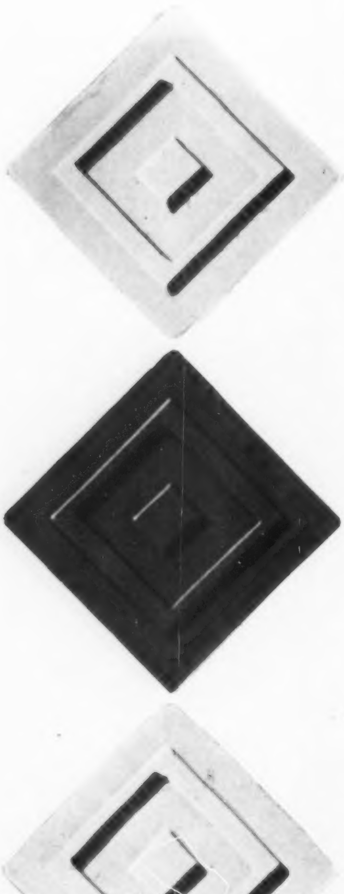
The interior and exterior, ramp and retaining wall alike are all built of reinforced sandblasted, integrally colored concrete, the tones and surfaces of which adapt to the architecture and to the site. Forming the concrete for changing curves and planes of the ramp alone was a unique problem.

Though Catholic in faith, as a work of art the chapel has a universal appeal and its doors will be open to everyone, regardless of creed. END



Blow the trumpets and beat the drums for this amazing way of getting glass-like concrete surfaces!

Plastic Form Liners Make Their Bow



WE KNOW the head for this article smacks somewhat of a carnival barker's line, but here's a new development which calls for an enthusiastic announcement. Just placed on the market is a plastic form liner material which produces a concrete surface of unbelievable smoothness.

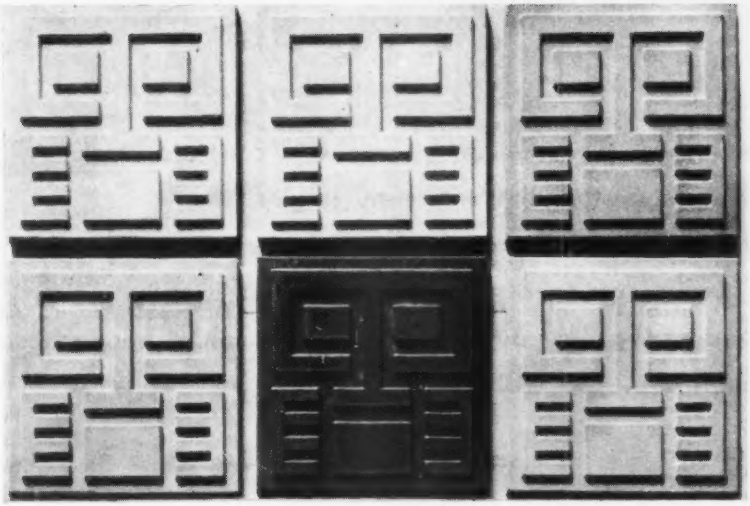
Without exception, everyone who has seen panels made with the liner has been amazed at the finish. Many comment on' its similarity to glazed surfaces. The most appealing part of all is that the surface is achieved without resorting to any special mix or kiln curing.

Called Lustreform No. 2900, the lightweight material can be easily formed into any suitable pattern. Patterns can be of wood, plaster or glass with wood seeming the best choice for most designs. It has been found advisable to follow a few rules for ease of stripping: to limit design depth to ½ inch, make all corners and edges rounded, and have at least a 6-degree slope on the edges of protruding areas. If a relief of more than ½ inch is desired, depressed areas should be of greater width. Stripping will be simple if these hints are adhered to by the designer.

Greatest success has been had so far with horizontal surfaces either precast on the site or factory precast. Cast-in-place vertical work has been troublesome since air tends to collect in the crevices of the liner and cause voids. This doesn't seem an insurmountable problem, however, and no doubt some simple means to overcome it will be found.

Any standard concrete mix can be used with the liners. Lightweight aggregates will probably be widely used for precast units to reduce their weight.

Concrete surfaces with a single, simple design produced by the new plastic liners can be cast in several designs. Use of contrasting colors extends the effects that can be achieved.



Air-entrained concrete, with three to five per cent air, is especially well adapted because of its improved workability.

Precast units should be vibrated on a high-speed table vibrator. For deep sections and cast-in-place concrete, pour in 10- to 12-inch lifts and thoroughly vibrate each pour. The liner must remain in place 48 hours, and preferably three days, to achieve the high sheen and beautiful color it is capable of producing. Exposed surfaces should be covered during the curing period. **Do not use any form oil!** After stripping, rinse down the surface with water and rub with a clean cloth.

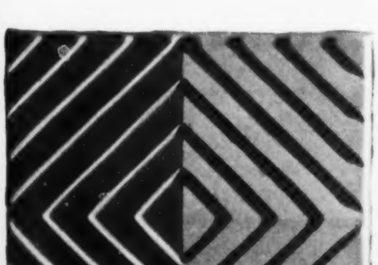
After 10 to 12 reuses, the liner will probably require a thorough cleaning with the special fluid available from any dealer that handles the liner material. If desired, liners can be rinsed after each use with the fluid rather than with water to eliminate the need for the extensive treatment after every 10 to 12 reuses. In any case, the usable life of the liners is great.

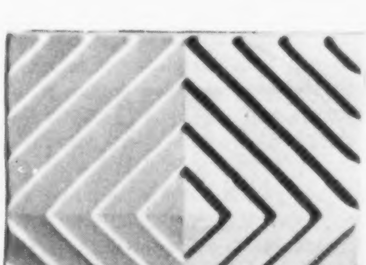
When using lightweight aggregates, the following mixing routine is suggested for highest strengths and smoothest surfaces: (1) mix the coarse and fine aggregates and ⅔ of the water for two minutes; and (2) add the balance of the water and the cement (also the air-entraining agent and/or coloring agent, if used) and mix three minutes more.

Some apprehension has been expressed regarding the weathering qualities of these surfaces and tests are presently in progress to determine their durability. If this type of surface is to be used under conditions of considerable weathering, it would be best to coat the surface with a silicone solution containing 4 to 5 per cent of silicone.

Unfortunately, the beauty of the surface produced by these plastic liners does not come across very well in photographs. But you'll soon be seeing it in the actuality since its striking advantages of low cost, satin-like sheen, clear colors and ease of use will undoubtedly find application readily. One of the architects who saw some test panels has already changed his plans for a large building to incorporate their use.

Distributorships throughout the country have already been set up to handle Lustreform No. 2900. Plastic form liners have been launched and they seem certain to become an important element in concrete construction work. We will report on further developments as soon as actual field experience has been gained. END





Although the problem of cracks in concrete work has been studied from many angles, the main line of attack still seems to lie in one direction —preventive measures at the time of placing and curing. If you want to avoid a lot of headaches, therefore, you will . . .

Put Crack Prevention On Your Construction Schedule

IS CRACKING actually a more serious problem in concrete construction work today than it was some 30 years ago, or does this just seem to be true because we are now doing relatively difficult things with concrete? Few questions that apply to the field are more likely to touch off a heated debate.

The truth seems to be that cracking *is* one of our more serious problems, and at least a fair share of the trouble can be attributed to modern construction practices which sacrifice quality for haste. There is little doubt, for example, that we had less trouble with cracks in the days when we were content to use low-cement concretes which gained strength slowly, and when it was possible as well as economic to expend the additional man hours of labor necessary to place, consolidate and finish low-slump concretes.

Regardless of how the apparent aggravation of the cracking problem is explained, it is a mistake to adopt a resigned attitude toward the subject. Most cracks can be readily explained, and once the cause is understood preventive steps can be taken.

The accompanying sketches represent an effort to show pictorially some of the more common types of cracks and to explain what causes them. They are the work of T. Boyd Mercer, a well

Fig. 1—Crack caused by constructional movement downward of subgrade.

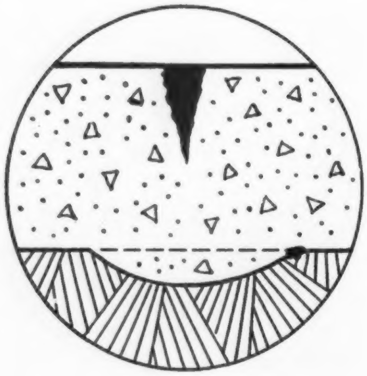


Fig. 2—Movement of formwork, e.g. by swelling of timber, can cause crack.

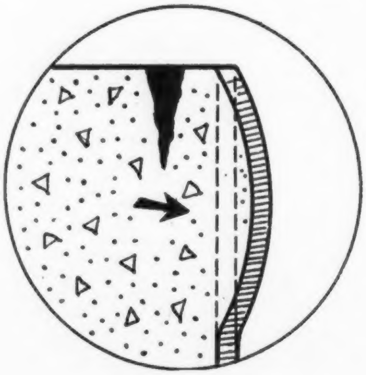
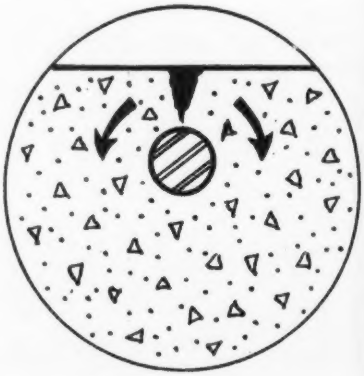


Fig. 3—Shrinkage of concrete around reinforcement can cause cracking.



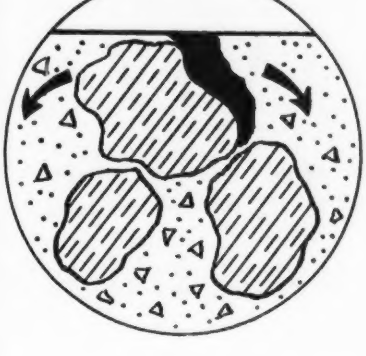


Fig. 4 (left)—This shows how a crack may be formed by shrinkage around aggregate.

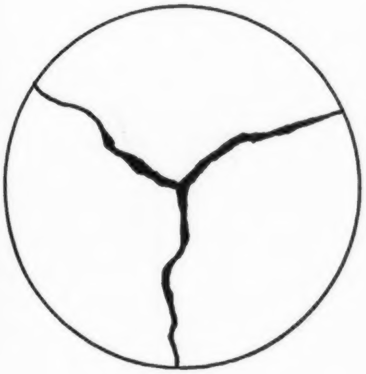


Fig. 5 (left)—Typical three-branched crack resulting from drying shrinkage.

Fig. 6 (right)—The plastic shrinkage cracks in this pavement were caused by the rapid evaporation of moisture from the concrete surface.

known Australian concrete engineer, and they were originally published in the September 1946 issue of *Commonwealth Engineer*.

Mr. Mercer classifies concrete cracks into two broad categories: he includes those that occur before hardening and those that occur after hardening. Subtypes in the before-hardening category are constructional movement; settlement shrinkage; and setting shrinkage. After-hardening cracks are classified under six headings: physical, chemical, temperature, stress concentrations, structural design and accident.

BEFORE-HARDENING CRACKS

Figure 1 shows the type of crack which is likely to develop when the subgrade subsides after concrete is placed but before it has had time to develop much strength. The best preventive measure is to make sure that the subgrade is properly compacted. The same type of crack may occur when concrete is poured on building paper which has been laid over irregular subgrades. When the paper, weakened by moisture, subsides into subgrade hollows just as the surface of the concrete is setting, surface cracks are almost inevitable.

Figure 2 shows how the movement of formwork can cause concrete to crack. Form movements of even small magnitude during the early stages of the hardening process are likely to cause trouble. Such movements may be caused by improper form design, by swelling of form lumber due to moisture, or by loosening of nails due to improper or excessive use of vibrators. The method of prevention, at any rate, is obvious.

Figure 3 shows a crack formed by the shrinkage of concrete around a reinforcement bar. It is believed that this type of crack occurs when the upper surface of the concrete takes on a partial set while the solid particles of aggregate below the surface are still setting. When this interior settlement takes place around a rigid obstacle, such as a reinforcing bar, vertical cracks tend to form in the surface above the bars.

Preventive measures include the use of dense plastic mixes and giving more attention to the compaction of the concrete. As a corrective measure it is recommended that final floating be delayed until the internal settlement and the resulting cracking have taken place, or that the concrete be revibrated in the event it can no longer be worked successfully (See "A New Look at Revibration," Concrete Construction, September 1956, page 2.)

Figure 4 shows how a crack may be formed by the shrinkage of the concrete around aggregate particles. Mechanically this type of cracking is quite similar to the type shown in **Figure 3,** and the same preventive measures are recommended. The phenomenon seems to occur when the aggregate particles form a skeleton through which the cement paste can settle and separate.

Figure 5 shows the typical three-branched crack that often results from drying shrinkage. This type of crack can best be prevented by retention of the water.

Figure 6 shows an actual photograph of plastic shrinkage cracks in a concrete pavement. Cracks of this type usually appear when wind velocity, low relative humidity, high air temperature, or a combination of all three, cause water to evaporate from a concrete surface faster than it is replaced by bleeding. MORE

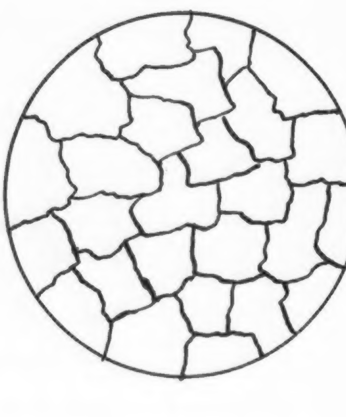


Fig. 7 (left)—Crazing of concrete from reaction of cement with carbon dioxide of air.

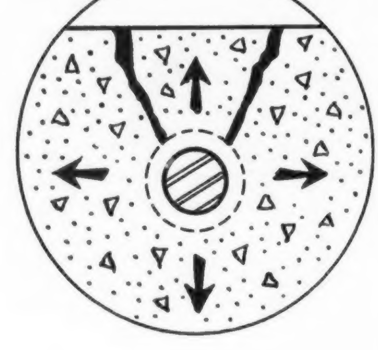


Fig. 8 (right)—Cracking resulting from pressure exerted by oxidation of the reinforcement.

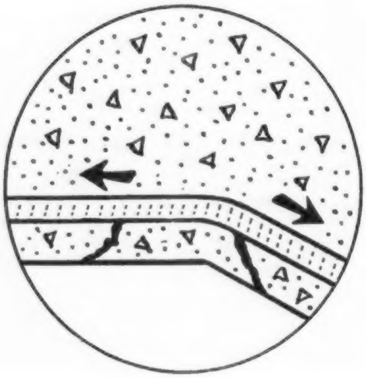


Fig. 9 (left)—Cracking due to stress concentration at the bend of a reinforcement rod.

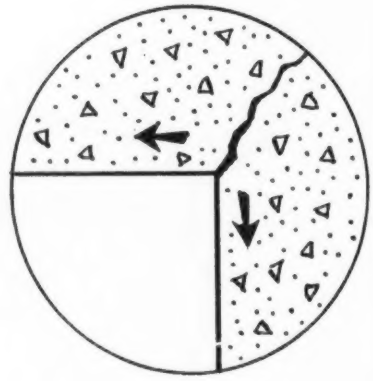


Fig. 10 (right)—Crack at angle resulting from concentration of tensile stress in concrete.

The rapid evaporation which is responsible for this type of cracking can be controlled by such measures as the following: erecting windbreaks; shading the concrete surface from the direct rays of the sun; cooling the concrete in hot weather and avoiding overheating in winter; by the application of protective coverings, such as membrane curing compounds, paper, film, wet burlap or sand, as soon as possible; and by dampening subgrades and forms before pouring. (See "Plastic Cracking Can Be Prevented," Concrete Construction, September 1956, page 8.)

AFTER-HARDENING CRACKS

After-hardening cracks must necessarily cover almost anything that happens to concrete after its form can no longer be altered without damage. In this category come the cracks caused by the later stages of drying shrinkage, as well as those which result from the moisture movements which take place in almost all materials as they are subjected to alternate stages of wetting and drying.

Moisture movements can cause serious cracking unless the structure permits them to take place without developing excessive stresses, or some provision is made to withstand the stresses when they occur.

Figure 7 shows the crazing effect that sometimes occurs in concrete surfaces due to carbonation. It is the result of a chemical reaction between the cement and the carbon dioxide in the air. Crazing may also be caused, however, by excessive floating, which has a tendency to draw water and fines to the surfaces resulting in weak concrete subject to high shrinkage stresses.

Cracking can also be caused by reactions between certain chemically reactive aggregates and high alkali cements. Reactions of this sort are usually accompanied by enough expansion to develop destructive internal stresses. In areas where reactive aggregates are known to exist specifications usually place a limit on the percentage of alkalies allowable in the cement.

Figure 8 shows the kind of cracking that some times takes place in concrete due to the oxidation of reinforcing steel. The most frequent causes of this type of trouble are failure to provide sufficient cover for the steel and excessive porosity of the concrete. Structures subject to alternate wetting and drying, especially in sea water, are most vulnerable.

Figure 9 shows cracking caused by the concentration of stress at the bend of a reinforcing bar. This condition usually occurs when there is insufficient concrete over the reinforcement to withstand the stresses which concentrate at points of direction change.

Figure 10 shows another example of cracking caused by stress concentration. In this case the structural form required an opening and no provision was made for the stresses which are bound to concentrate at the corners. Doors, windows and similar openings in concrete should always be provided with reinforcement at the corners.

Everybody in the complicated chain of responsibility which extends from raw material deposits to a finished structure of concrete must share some part of the responsibility for the prevention of cracks. Vigilence and conscientious effort all along the line can do much to eliminate most of the more common sources of trouble. END

READY-MIX PRODUCTION HITS NEW HIGH

A NEW STUDY just released by the National Ready Mixed Concrete Association points up the growing importance of concrete construction to the nation's economy. The association's survey of commercial production of ready-mixed concrete in 1956 indicates that the industry's total output probably increased by not less than 13 percent, far outstripping the gain in total dollar volume of construction.

By a wide margin California led all other states in the production of ready-mix last year. The Golden State also outran the field with a whopping 25 percent production gain over 1955. Other states among the top ten, in the order of their rank in the survey findings, were Ohio, New York, Illinois, Michigan, Pennsylvania, Texas, Florida, Massachusetts and Indiana. These same states also all ranked among the first ten in the association's study of 1955 production.

The NRMCA findings were based on production statistics covering 1,247 companies out of a total of 2,314 to which questionnaires were sent. Actual production reported amounted to a little over 73 million cubic yards with a total volume of over $962½ million. Projection of the average production of 58,670 cubic yards per company for the reporting group to cover all the sources known to the association indicates that total output could have been as much as 136 million cubic yards. The comparable figure for 1955 based on similar data was 119 million cubic yards.

The survey findings indicate that ready-mixed concrete produced in 1956 had an average value of $13.16. This represented an increase of 67 cents per cubic yard over the $12.49 figure reported for 1955.

As in 1955, home building in 1956 accounted for over 30 percent of all the ready-mixed concrete sold. Home-building's share of the total reported yardage was down slightly (to 31 percent compared with 34 percent in 1955). Industrial construction accounted for 16½ percent of the total, compared with only 14½ percent in 1955, and consumption in street and highway work was up to 12½ percent of the total reported yardage (from 10½ percent in 1955). Other use categories showed little change: Federal public works was unchanged at 3½ percent; non-Federal public works was down slightly to 7½ percent; and farm consumption edged upward to 2 percent of the total.

Among the reporting companies, dry batching plants outnumbered central mixing plants in the ratio of about 1.7 to 1. The average number of truck mixers or agitators per company was 15.2, whereas the comparable figure for 1955 was 13.6.

With home building in the doldrums, there seems little likelihood that the ready-mix industry will chalk up any new records for the current year, unless volume losses in the home market are recouped in the road building program. Some aggressive firms in the field are already definitely "on the make" for a larger share of the road-building dollar. If ready-mix can crack this market in the years just ahead, there is every reason to believe that this still-quite-new industry may continue the sensational production gains and overall growth pattern which have marked its history to date. END

How Ready-Mixed Concrete Was Used in 1956

HOME BUILDING	31%
COMMERCIAL CONSTRUCTION	17%
INDUSTRIAL CONSTRUCTION	16½%
STREETS AND HIGHWAYS	12½%
NON FEDERAL PUBLIC WORKS	7½%
FEDERAL PUBLIC WORKS	3½%
FARM CONSTRUCTION	2%
ALL OTHER CONSTRUCTION	10%
TOTAL	100%